

NOTE ON AN APPARENT TREND IN ANNUAL PRECIPITATION AT NEW YORK CITY¹

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ABSTRACT

An apparently significant secular trend in annual precipitation at Central Park in New York City is found to be anomalous.

1. INTRODUCTION

Namias [1] has recently called attention to an apparent decline in annual precipitation which the authors found in an analysis of the record of the New York City Central Park Observatory of the Weather Bureau. The purpose of this note is to report on a further study which indicates that the apparent trend at Central Park does not appear to be representative of the New York City area.

2. THE CENTRAL PARK RECORD

The weather observatory in Central Park has been located within 1 mi. of its present location since 1869. Until January 1920 the raingages (tipping bucket and standard 8-in. stick gage) were located 64 ft. above ground on the roof of the Arsenal Building on Fifth Avenue, the east boundary of the Park. In 1920 the raingages (now including a weighing gage) were moved 1 mi. to the west, to a terrace location 22 ft. above ground at the Belvedere Tower. In 1951 the Universal weighing raingage replaced the tipping bucket gage as the official Central Park raingage, and in 1962 the weighing raingage was moved to a nearby area on the ground enclosed by a chain link fence. At no time, according to the New York City Office of the Weather Bureau, has a shield been used on the raingages. No construction has taken place in the vicinity of the raingages since 1920, and only normal tree growth has altered the character of the local exposure. There is no record of any other changes in procedure or exposure for the Central Park Observatory since 1920 [4].

Visual examination of the record of annual precipitation from Central Park (see fig. 6 in [1]) indicated the existence of a downward trend, especially for the period beginning about 1926. A linear least squares analysis of the record for the 40-yr. period, 1926–1965, yielded a linear trend coefficient of -0.298 in./yr. with 95 percent confidence interval, -0.149 to -0.448 . For the 97-yr. period, 1869–1965, the trend coefficient was found to be -0.047 in./yr. with 95 percent confidence limits, -0.003 and -0.091 .

As the motivation for this study was the great northeast drought of 1962–1966, there is an inherent bias in the analysis resulting from the existence of a dry period at the end of the record. It is therefore necessary to delete the drought years in order to obtain an unbiased estimate of the trend. The least squares computations were repeated for the periods 1926–1961 and 1869–1961, and the linear trend coefficients and 95 percent confidence limits for these periods were found to be -0.217 in./yr. (-0.045 to -0.390) and -0.023 in./yr. (-0.008 to -0.039), respectively.

The above results indicate statistically significant downward trends in annual precipitation at Central Park for the historical period, even with the recent drought years excluded, with a strikingly larger downward trend during the past 40 yr. If this result is valid and geographically extensive, it would suggest that the great drought was associated with a long-term decline in annual precipitation in the New York area, a conclusion that could have important social and economic significance.

3. COMPARISON WITH REGIONAL PRECIPITATION

The geographical extent of the apparent trend in annual precipitation at Central Park was investigated by analyzing all available precipitation records for the period since 1926 from raingages within about 100 km. of New York City. The results of the linear least squares trend analysis of the 28 stations in the group, together with comparative results for Central Park, are shown in table 1 for the periods 1926–1965 and 1926–1961.

As shown in table 1, only four stations in addition to Central Park (Bridgeport, Chatham, Little Falls, and New Milford) exhibit statistically significant negative trends in annual precipitation for the period 1926–1965. (Statistical significance at the 95 percent level is indicated by an asterisk.) However, when the drought years are deleted, although these stations still exhibit negative trends, none of them is statistically significant. Indeed, whereas all but two of the 28 stations surrounding New York show negative trends for the period 1926–1965, only seven of the stations have negative trends for the period 1926–1961. Thus, it appears that the trend found in the Central Park record for the period beginning in 1926 is not representative of the area around New York City.

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² Portions of this paper are taken from a thesis submitted by P. Ronberg to New York University in partial fulfillment of the requirements for the Master of Science degree.

TABLE 1.—Linear trends of annual precipitation, by least squares, for the periods 1926–1965 and 1926–1961. Asterisks (*) indicate that the trend coefficient is significant at the 95 percent probability level. The right-hand columns indicate the number of station moves since 1926 and the year of the last move.

State	Station	Trend coefficients (in. per yr.)		Number of station moves, 1926–1965	Year of last station move
		1926–1965	1926–1961		
Connecticut...	Bridgeport†	*-0.407	-0.024	2	1948
	Norwalk	-0.108	+0.114	1	1955
New York...	Central Park†	*-0.298	*-0.217	0	
	Bedford Hills	-0.100	+0.110	0	
	Boyd's Corner	-0.141	+0.058	0	
	Carmel	-0.138	+0.020	0	
	Middlebranch Reservoir	-0.173	-0.005	0	
	West Point	+0.181	*+0.416	1	1946
	Warwick	+0.024	+0.223	1	1936
	Setauket	-0.072	+0.053	0	
New Jersey...	Scarsdale	-0.014	+0.162	1	1942
	Trenton†	-0.061	+0.025	1	1933
	Hightstown	-0.136	-0.053	5	1935
	Flemington	-0.066	+0.070	1	1948
	New Brunswick	-0.099	+0.043	0	
	Newton	-0.137	+0.057	1	1946
	Branchville	-0.068	+0.102	2	1954
	Sussex	-0.145	+0.032	5	1954
	Somerville	-0.113	+0.020	7	1946
	Plainfield	-0.137	-0.006	4	1948
	Chatham	*-0.291	-0.121	1	1943
	Boonton	-0.041	+0.138	0	
	Little Falls	*-0.223	-0.057	0	
	Woodcliff Lake	-0.082	+0.098	0	
	New Milford	*-0.178	-0.028	0	
	Paterson	-0.047	+0.143	10	1948
	Elizabeth	-0.051	+0.181	1	1926
	Newark†	-0.140	+0.008	2	1941
	Jersey City	-0.111	+0.024	3	1943

†First order Weather Bureau Stations. All others are cooperative stations.

It might be argued that the station records employed in table 1 may be inhomogeneous or defective in other respects. (The anomalous result for West Point, indicating a highly dubious significant positive trend for the period 1926–1961, is a case in point.) To reduce the effects of such errors in the individual station records, a 28-station regional average record was computed and analyzed. For the periods 1926–1965 and 1926–1961 the linear trend coefficients for the regional average were found to be -0.109 and $+0.049$ in./yr. respectively, neither of them statistically significant. Again, the representativeness of the Central Park record appears doubtful.

From Weather Bureau records for the stations listed in table 1, the number of station moves since 1926 and the year of the last station move were determined. As shown in the table, only 10 of the 28 stations have remained at one site for the entire period. However, no obvious systematic bias appears to be associated with station moves. Of the four stations which exhibit significant negative trends for 1926–1965, two have moved and two have not. Of the seven stations which exhibit (non-significant) negative trends for the period 1926–1961, four have moved and three have not. Of the 10 stations which have not moved, only three exhibit negative trends (non-significant) in the period 1926–1961. Thus, the apparent nonrepresentativeness of the Central Park record does not appear to be associated with inhomogeneities of the comparison stations.

4. COMPARISON WITH BATTERY PLACE

The evidence above strongly suggests that the apparent Central Park trend over the past 40 yr. is not repre-

sentative of regional precipitation over an area with radius 100 km. centered on New York City. To determine if it is representative of New York City itself, a comparison was made with the record of the Weather Bureau's Battery Place station.

Battery Place is located at the southern tip of Manhattan Island, about 5 mi. south of the Central Park Observatory. From 1911 until the closing of the station at the end of 1960 the raingage was located on the roof of a building, 398 ft. above sea level. This is the only station record from New York City known to the authors that is available for comparison with Central Park for the period beginning 1926 or earlier.

The linear trend of annual precipitation at Battery Place from 1926 through 1960 was found to be $+0.026$ in./yr. (not significant). This compares well with the trend of the regional average for the period 1926–1961 ($+0.049$), and again fails to substantiate the result for Central Park.

The linear correlation coefficient between annual precipitation at Battery Place and the 29-station regional average (stations listed in table 1) for the period 1926–1960 was found to be $+0.80$. This may be compared with correlations of $+0.69$ between Central Park and the regional average for 1926–1961, and $+0.69$ between Battery Place and Central Park for the period 1926–1960. The correlation coefficients lend support to the argument that the Battery Place record is more representative of the region than that of Central Park.

Further comparison of the Central Park and Battery Place records for the period 1921–1960 has failed to reveal a clear-cut explanation of the apparent discrepancy. It was noted that prior to 1942 the ratio of annual precipitation at Central Park to that at Battery Place was ≥ 1 in 20 out of 21 yr., with a mean value of 1.07, while from 1942 through 1960 the ratio was < 1 in 15 out of 19 yr., with a mean value of 0.94. Two tests for homogeneity [5] of the Central Park record were applied to the period 1921–1960 using Battery Place as a comparison station. The Mann-Kendall rank statistic test indicated that the record was inhomogeneous at the 0.001 probability level, while the Spearman rank test indicated inhomogeneity at the 0.003 level. However, nothing in the history of the station could be found to account for the apparent discontinuity in the year 1942.

5. SEARCH FOR TRENDS IN LONG PRECIPITATION RECORDS

Following the discovery of the Central Park trend, 339 additional records of annual precipitation from stations in the northeastern United States were subjected to linear least squares analysis.³ Of these, 53 station records were considered to be "long" records, having begun no later than 1876.

³ The records analyzed were first adjusted for station moves and for gaps in the record, where necessary.

The average of the linear trend coefficients for all 53 "long" records for the period through 1961 was found to be -0.008 in./yr. (The lengths of these historical records varied from 86 to 148 yr.) The sample contained 29 negative coefficients and 24 positive coefficients. Of the former, nine (including Central Park), were found to be significant at the 95-percent level, while of the latter, five were significant at the 95-percent level. The remaining 39 trends were statistically nonsignificant. No coherent geographical pattern of trends was found. Thus, despite the somewhat excessive numbers of "significant" negative trends, the analysis of the "long" precipitation records indicates little or no evidence of a geographically extensive decline in precipitation over the northeastern United States in the past century.

Among the 53 "long" precipitation records in the northeastern United States, 18 "very long" records were found, extending back to at least 1840. In this group 10 negative and eight positive trend coefficients were computed for the period through 1961, with two of each sign indicating significance at the 95-percent level, but with no geographically coherent pattern. Again there is no evidence of a geographically extensive long-term trend in annual precipitation in the northeastern United States. This conclusion is consistent with the results of studies by Thom [2,3] for the same region.

6. CONCLUSIONS

The apparent downward trend in annual precipitation at Central Park is not substantiated by records from other stations in New York City, in the surrounding region, or in the northeastern sector of the United States. Although there appears to be an inhomogeneity in the Central Park precipitation record, no obvious reason for it could be found.

One may speculate about possible physical causes for a real local anomaly in annual precipitation at Central Park. However, it will be difficult to demonstrate quantitatively that urban influences such as air pollution, heat island effects, etc. can account for the apparent phenomenon. It appears at least equally likely that the phenomenon is not real.

The result of this study is another illustration of the difficulty of deducing climatic trends from meteorological data even when the record is apparently homogeneous with respect to station location and exposure. The problem is obviously further complicated when inhomogeneities are introduced by changes in station location and exposure, as well as type of raingage.

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